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GB 2002986 A GB 1520154 A EP 0015199 A

(58) Field of Search
UK CL (Edition J) F3C, G1A, H4D
INT CL[4] F41G, G01B, G01S

(54) **System for determining the orientation and location of a moving body with respect to a structure**

(57) The system enables the spatial referencing of one or more directions (DR) associated with the moving body eg. a helmet aiming sight, and its location. It uses two sensors (2, 3) formed from a solid matrix (4, 5) made of charge-coupled devices. These sensors are carried by the structure (1) eg. an aircraft cockpit, and are advantageously formed by miniature cameras (2, 3) sensitive in the infra-red range. Three sources (21, 22, 23) arranged at the points of a triangle are carried by the helmet (20) and may consist of IR light emitting diodes. The referencing is based on the fact that the detected spot image, the centre of the associated optical objective (6, 7) and the corresponding emitting source are aligned, which enables, by means of computation, the determining of two straight lines, their intersection at the source point, and, consecutively, the location of the three sources and of the direction DR to be referenced.

FIG_1

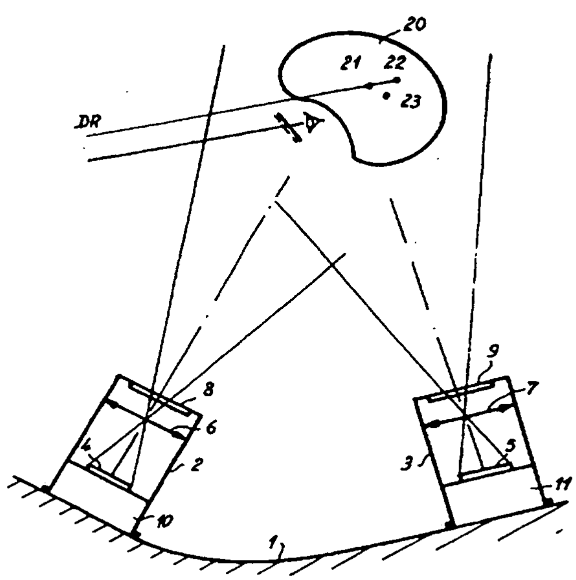

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FIG_1

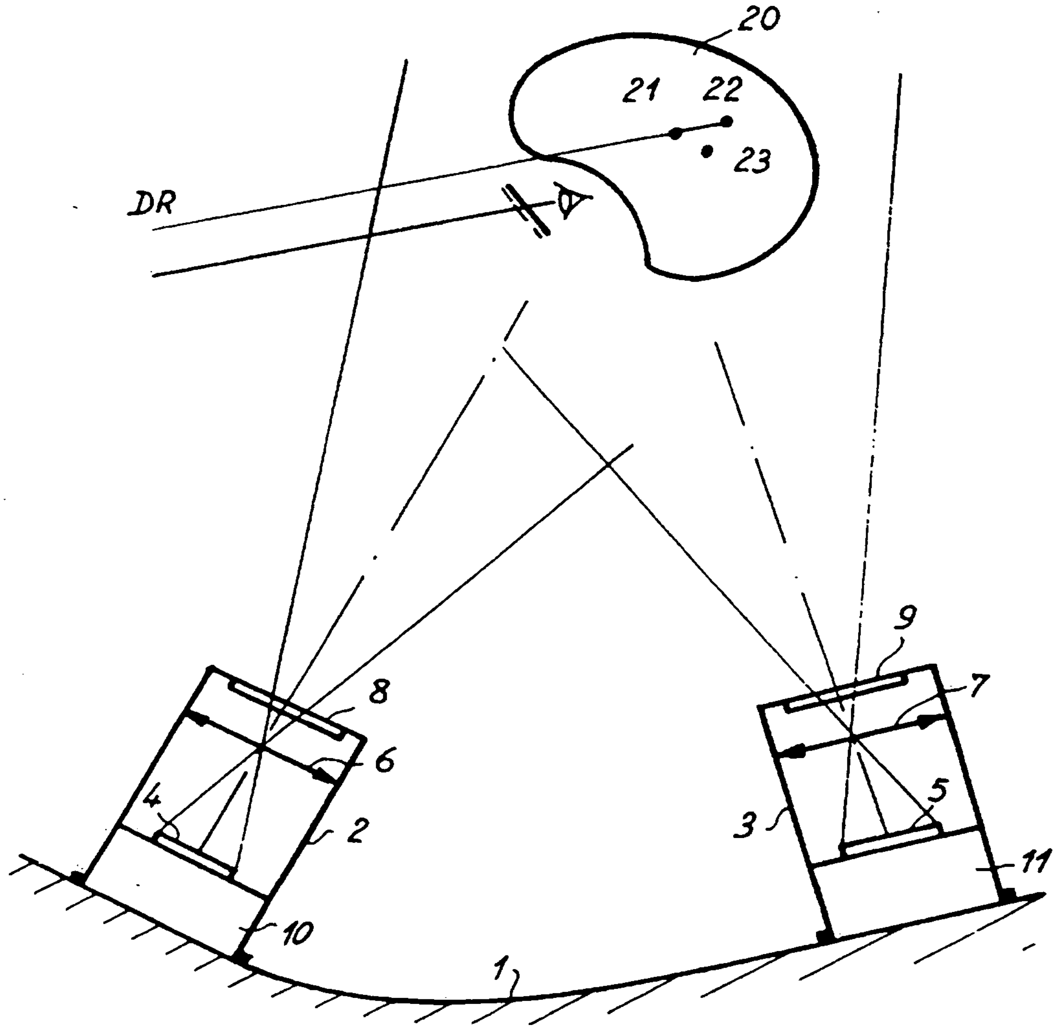
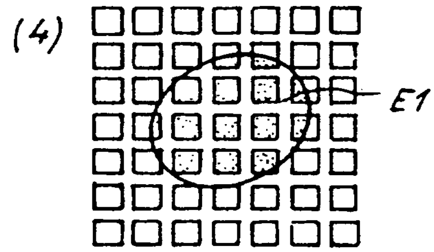


FIG_4



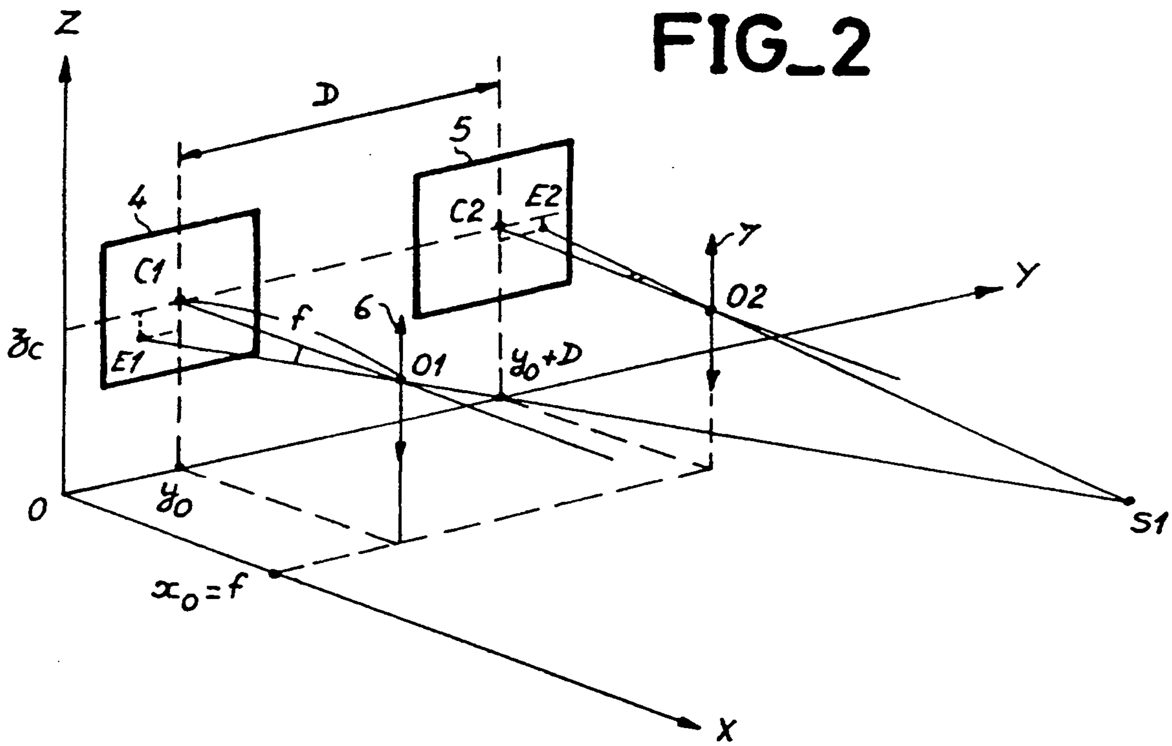
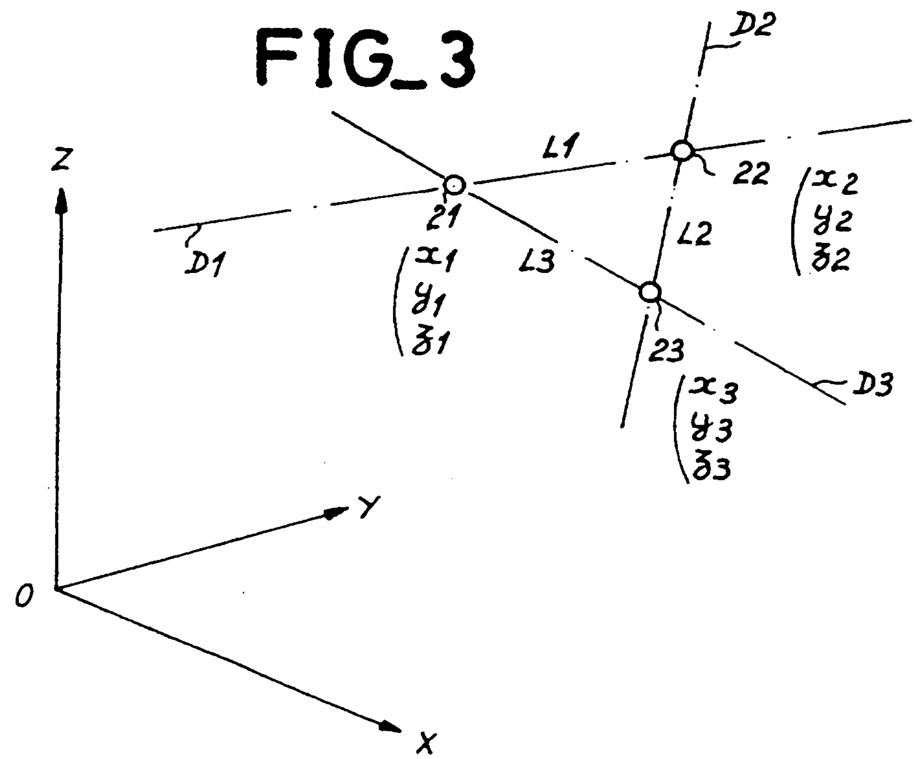

Z
D
5
4
C1
C2
E2
7
Y
6
f
O2
ʒc
E1
O1
y_o+D
O
y_o
S1
$x_o=f$
X

FIG_2

FIG_3


D2
Z
L1
22
21
L2
D1
L3
x_2
y_2
z_2
x_1
y_1
z_1
23
D3
x_3
y_3
z_3
Y
O
X

2301966

A SYSTEM FOR DETERMINING THE ORIENTATION AND LOCATION OF A MOVING BODY WITH RESPECT TO A STRUCTURE, USABLE IN PARTICULAR FOR A HELMET AIMING SIGHT

16 JUN 1987

The present invention relates to a system determining the orientation and location of a moving body with respect to a structure by carrying out a referencing of directions associated with this body. Its use is more particularly envisaged in the aeronautical field where the moving body is constituted by the helmet of the pilot fitted with an aiming sight and the structure is constituted by the cockpit.

Systems of this type are produced in various ways which are divided into two major categories; optical solutions and magnetic solutions. The object of the invention refers to an optical type solution. Such a solution can be constituted by a group of light emitting diodes mounted on the helmet, one or more sensors mounted on the cockpit and an associated computer which processes the detected signals in order to measure the reference direction associated with the helmet. A successive sequential feeding of the diodes is produced by the computer. The sensors are mounted in a fixed way in the aircraft and the computer can, at any time, give the spatial position of a defined direction associated with the helmet, this reference direction preferably being chosen to be corresponding with the aiming direction of the pilot. A solution of this type is described in particular in the French Patent 2 399 033. The sensor is constituted by a detector device preferably formed from three subassemblies each including a linear array of photo-sensitive elements coupled with a cylindrical diopter of perpendicular direction in order to determine three planes passing through the light emitting source and to produce, by an additional computation, the corresponding spatial location of that source, then that of the triangle formed by a set of three sources and, consecutively, to determine the direction to be referenced.

A big disadvantage of these devices is in the fact that the optical efficiency is very poor, given that the slit associated with the cylindrical diopter is approximately 150 microns wide and that the light energy transmitted by the light emitting source through this optical system and this slit and arriving at one or more elements of the detector array remains very limited.

According to another known solution described in the French Patent 2 433 760, the helmet returns a radiation by back-reflection and this radiation falls on an XY matrix of elements electrically controlled by a control circuit and by a computing circuit in order to make the elements pass from the opaque state to the transparent state according to a predetermined selection program. A single photo-detector downstream of the matrix feeds the computing circuit which provides the angular deviation measurement of the back-reflector device. Several back-reflectors are provided to act as diodes and thus to determine a direction associated with the helmet. According to this solution the electrically controlled matrix can be produced from liquid crystals of nematic type or by a PLZT ceramics-based optoelectric shutter device. Such a solution proves to be complex, its installation delicate and its use requires a certain period of time in order to scan the matrix element by element.

The object of the invention is to produce a system for the spatial referencing of direction which enables the disadvantages of the abovementioned solutions to be remedied by using solid-state circuit matrix detector structures.

According to the invention there is proposed a system determining the orientation and location of a moving body with respect to a structure, using means of emission carried by the body and means of opto-electric detection carried by the structure in order to define, by the analysis of the detected signals and by the computation of the secant planes and by the straight lines of

intersection of these planes, at least one direction associated with this body, the means of emission being constituted by a plurality of at least three point light sources with an omnidirectional radiation diagram, wherein the means of opto-electric detection are solid matrix sensors produced from charge transfer circuits known as CTD devices, the matrices being at least two in number, each coupled with a receiving optical system, the assembly enabling, by the analysis of the detected image, the determination of the coordinates of the spot image of each of the sources and, consecutively, the straight line passing through this point and the centre of the asociated receiver objective which also passes through the corresponding emitting source, such that each source is determined by at least two secant straight lines, the spatial location of the sources determining the orientation of the moving body, its location and the spatial referencing of the directions associated with this body.

The features and advantages of the invention will become apparent in the following description given by way of non-limiting example with reference to the appended figures which show,

- in Figure 1, a general diagram of a system in which the invention is embodied;
- in Figure 2, a diagram illustrating the method of spatial referencing used;
- in Figure 3, a diagram illustrating the referencing of several directions of the body and its location with respect to the structure;
- in Figure 4, a detail drawing which illustrates the accuracy of the measurement.

Referring to Figure 1, the system is considered in a non-limiting way in an application to a helmet aiming sight. The cockpit 1 of the aircraft is equipped with two solid matrix miniature detector cameras. These cameras, 2 and 3, each group the actual opto-electric sensor, referenced 4

and 5, produced from CTD (CCD is the English abbreviation for "Charge Coupled Device") circuits, a receiving optical objective 6 and 7 and possibly a means of optical filtering, for example an interferential filter 8 and 9. Behind each sensor there are generally found associated circuits 10 and 11 for reading, preamplification and possibly circuits for processing the detected video signals. The means of opto-electric detection defined by these two cameras enable the receiving and processing of a specified radiation in an also specified field. The intersection of these fields represents a spatial volume in which the moving body to be referenced can move. In this application to a helmet aiming sight, the moving body is constituted by the helmet 20 of the pilot which carries a set of at least three light emitting diodes 21, 22 and 23. These diodes are placed at the points of a triangle, preferably of any triangle. One side of this triangle can represent the direction DR to be referenced which advantageously corresponds with the aiming direction of the pilot.

The technique used according to the present invention enables the referencing of a point in space in a way that is comparable with the referencing carried out by the eyes. In the prior art, the arrays used were not capable of spatially simulating a retina. There are now available on the optoelectronics market charge transfer device matrices which can be compared with a retina. The photosensitive surface is formed of elements distributed in an XY matrix. These matrix sensors are mainly used in video cameras. By projecting an image through the objective onto the photo-sensitive surface, after an integration time, it is possible to read each photosensitive pixel and to produce a video image. In the envisaged system a detection set of two eyes is simulated by means of two CTD circuit solid matrices.

The spatial determination of an emitting point is easily obtained from the image point and, taking into account that this image point is aligned with the emitting source

and the center of the associated objective along a straight line; the coordinates of the image point being known in the matrix and the position of the matrix with reference to the reference axes representing the structure being known, it is easy to derive, by the computation, two straight lines which intersect at a point corresponding with the location of the emitting point source.

This measuring technique is shown in greater detail in Figure 2 where, for purposes of convenience and simplification of explanation and computation, it is considered that the two matrices are coplanar, contained for example in the plane OZY of the XYZ trihedron associated with the structure 1.

The distance D between the centers C1 and C2 is that of the spacing between the sensors and constitutes a first known parameter. It is considered that the cameras are identical and that the distances C1 01 and C2 02 of these two centers from the objectives 01 and 02 are the same and equal to the focal length f of the objective. A point source S1 has been considered, its light radiation is focused respectively at the image point E1 on the matrix 4 and at the image point E2 on the matrix 5. By reading these sensors line by line and point by point the positions of the image points with respect to the corresponding center is derived, i.e. the coordinates of the point E1 with respect to C1 and those of point E2 with respect to C2. The coordinates of the centers C1 and C2 being known with respect to the Y and Z axes, the coordinates of the points E1 and E2 with respect to these axes and the distance E1 E2 separating these two points are easily derived. The straight line E1S1 must pass through the center 01 of the objective 6. The same applies to the straight line E2 S1 which passes through the center 02 of the objective 7. Consequently it is possible to determine by means of the computation, as the positions of 01 and 02 are known, the equations of the straight lines E101 and E202 and the common point S1 of intersection of these straight lines in the XYZ reference system.

Consequently, the source S1 has been located by its coordinates with respect to the XYZ reference system which represents the structure. As the source S1 is one of the sources of the group 21, 22, 23 (Figure 1), the location of the other point sources is carried out by means of a similar computation using corresponding image points. As shown in Figure 3, there is therefore known the three directions D1, D2 and D3 passing through the sides of the triangle formed by the sources 21, 22, 23, whose coordinates are known with respect to XYZ. It is possible to be satisfied with determining one of these directions, for example that of D1, which corresponds with the direction DR to be referenced. However, if the three directions D1, D2 and D3 are determined, taking into account that the dimensions L1, L2 and L3 of the sides of the triangle of the sources are known by construction, it is possible to derive the location and orientation of the moving body 20 which carries the sources with respect to the structure at any time by computation.

The use of optics has a great advantage with respect to the prior devices with slits and arrays considering the concentration of focused light energy in the focal plane in which the matrix is located.

Figure 4 shows a light spot formed in the plane of the matrix corresponding with the image point, E1 for example, and which generally covers several photosensitive elements known as pixels. It is therefore possible to increase the accuracy of the device by determining the center of the spot during the processing of the detected signals. There are two main methods. According to a first method, each illuminated elementary cell on the matrix is detected and the arithmetic mean is computed which gives an approximate value of the center of the spot. The approximation is directly linked with the pitch of the elementary cells of the matrix. According to a second method, each of the illuminated cells is detected by recording the level of received illumination for each of

them; this gives a much greater accuracy as this time the computation determines the barycenter of the light spot. Other methods can also be envisaged for minimizing the reading error inherent in the pitch of the pixels. One of these consists in multiplying the number of spatially coherent light sources with each other in order to increase the accuracy after an extrapolation computation.

In order to locate the body 20, the light sources, at least three, are placed at the points of a triangle, preferably any triangle, and can be simultaneously and continuously powered, a light image formed by the three corresponding points being produced on the plane of the matrix 4 and 5. In order to reference the two points 21 and 22, corresponding with the direction DR to be referenced (Figure 1), without ambiguity, an associated computer can periodically command the switching off of the third light source 23 during a period greater than that of the integration of the sensor such that only two light spots remain to be detected during this period.

The cameras 2 and 3 can be miniature cameras provided with infra-red filters 8 aod 9 in order to filter the radiation and light emitting diodes 21 to 23, emitting in the infra-red range, in order not to disturb the pilot by local sources emitting in the visible spectrum. It will be noted that absolute spatial referencing can be obtained on board an aircraft by using data provided by a vertical system in order to transpose, according to known techniques, the direction DR measured with respect to the aircraft axes, which are represented by the structure 1, into ground coordinates.

CLAIMS

1. A system for determining the orientation and location of a moving body with respect to a structure, using means of emission carried by the moving body and means of opto-electric detection carried by the structure in order to define, by the analysis of the detected signals and by the computation of the secant planes and by the straight lines of intersection of these planes, at least one direction associated with this body, the means of emission being constituted by a plurality of at least three point light sources with an omnidirectional radiation diagram, wherein the means of opto-electric detection are solid matrix sensors produced from charge transfer circuits known as CTD devices, the matrices being at least two in number, each coupled with a receiving optical system, the assembly enabling, by the analysis of the detected image, the determination of the coordinates of the spot image of each of the sources and, consecutively, the straight line passing through this point and the center of the associated receiver objective which also passes through the corresponding emitting source, such that each source is determined by at least two secant straight lines, the spatial location of the sources determining the orientation of the moving body and the spatial referencing of the directions associated with this body.

2. system according to Claim 1, wherein the sensors are constituted by two CTD matrix cameras.

3. A system according to Claim 2, wherein the cameras are miniature cameras.

4. A system according to Claim 2 or Claim 3, wherein the cameras are equipped with means of optical filtering in a wavelength band corresponding with the radiation emitted by the sources.

5. A system according to Claim 4, wherein that the said radiation is located in the infra-red range.

6. A system according to any of the previous claims, wherein ______ the light sources______ are simultaneously and continuously fed.

7. A system according to any of the previous claims, used for a helmet aiming sight on board an aircraft, wherein ______ the sensors ______ are mounted on the structure of the aircraft and the sources are placed at the points of a triangle on the helmet.

8. A system for determining the orientation and location of a moving body with respect to a structure substantially as described hereinbefore with reference to and as illustrated in the accompanying drawings.

Amendments to the claims have been filed as follows

CLAIMS

1. A system for determining the orientation and location of a moving body with respect to a structure, using means of emission carried by the moving body and means of opto-electric detection carried by the structure in order to define, by the analysis of the detected signals and by computation, at least one direction associated with this body, the means of emission being constituted by a plurality of at least three point light sources with an omnidirectional radiation diagram, wherein the means of opto-electric detection are solid matrix sensors produced from charge coupled devices known as CCD's, the matrices being at least two in number, each coupled with a receiving optical system, the system enabling, the determination of the coordinates of the detected spot image of each of the sources and, consecutively, the straight line passing through this spot and the center of the associated receiver objective which also passes through the corresponding emitting source, such that the position of each source is determined by at least two straight lines, the spatial location of the sources determining the orientation of the moving body, its location and the spatial referencing of the directions associated with this body.

2. A system according to Claim 1, wherein the sensors are constituted by two CCD matrix cameras.

3. A system according to Claim 2, wherein the cameras are miniature cameras.

4. A system according to Claim 2 or Claim 3, wherein the cameras are equipped with means of optical filtering in a wavelength band corresponding with the radiation emitted by the sources.

5. A system according to Claim 4, wherein that the said radiation is located in the infra-red range.

6. A system according to any of the previous claims, wherein ______ the light sources ______ are simultaneously and continuously fed.

7. A system according to any of the previous claims, used for a helmet aiming sight on board an aircraft, wherein ______ the sensors ______ are mounted on the structure of the aircraft and the sources are placed at the points of a triangle on the helmet.

8. A system for determining the orientation and location of a moving body with respect to a structure substantially as described hereinbefore with reference to and as illustrated in the accompanying drawings.

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PATENTS ACT 1977
EXAMINER'S REPORT TO THE COMPTROLLER UNDER SECTION 17(5)
(The Search Report)

Application No. 8713975

FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as be mentioned below) in the following subject-matter areas:-

UK Classification F3C (CGB, CGD, CGX) G1A (AEE); H4D (DL)

(Collections other than UK, EP & PCT:) Selected US speicifcations from IPC sub classes F41G, G01B, G01

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may inc only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim
X	GB A 2002986 (THOMSON-CSF) whole document	1,7
X	GB 1520154 (ELLIOTT BROS) whole document	1,7
X	EP A1 0015199 (THOMSON-CSF) whole document	1,7

CATEGORY OF CITED DOCUMENTS

- X relevant if taken alone
- Y relevant if combined with another cited document
- P document published on or after the declared priority date but before the filing date of the present application
- E patent document published on or after, but with priority date

Search examiner
K E WILLIAMS

Date of search
1 February 1988